Investigations of *Nysius* spp. and Other Insects at Haleakala, Maui During 1964 and 1965[1]

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Introduction

At the December, 1963 meeting of the Hawaiian Entomological Society, Dr. Walter Steiger, Department of Astro-Physics, University of Hawaii, and Mr. Richard Hansen, National Center for Atmospheric Research, Boulder, Colorado, requested assistance in seeking a solution to an insect problem at the Haleakala Observatory. During the late summer, fall, and early winter of 1963, operation of the solar koronagraph at the observatory was seriously curtailed due to interference from flying insects. Mr. Hansen later estimated that approximately 20% of the otherwise optimum period for operation of this instrument was lost due to insect interference. This apparently is caused by scattering of light from the wings and bodies of insects flying between the instrument and the sun.

At the January, 1964 meeting of the Society, President Sherman appointed a committee of three members, Dr. Peter Ashlock (Bishop Museum), Mr. Clifton Davis (Hawaii Department of Agriculture) and Dr. John Beardsley (University of Hawaii, Chairman) to investigate the problem. This paper summarizes the results of these investigations during the period of January 1964 through July, 1965[2].

Field Work

During January, 1964, conical wind-sock type insect traps were operated for two weeks by J. Harrel and D. Tsuda at several sites near the Haleakala Observatory to obtain data on insect flight activities. Results were reported at the February, 1964 meeting by Mr. Tsuda.

During the study period, I made 10 trips to, and spent 20 days on Maui. Approximately half this time was devoted to the study of *Nysius* bugs and other insects at the summit of Haleakala, while the remainder was spent surveying their populations at lower elevations on east Maui. In addition, Davis and Ashlock made two visits each, and W. C. Mitchell, assistant professor in the Entomology Dept., University of Hawaii, made one visit to the observatory area to investigate the problem. I am indebted to these gentlemen for their help and advice on this project.

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PHYSICAL AND BIOTIC ENVIRONMENT AT HALEAKALA OBSERVATORY

The University of Hawaii Observatory is situated, with several other scientific and communication installations, at the summit of Kolekole Peak, about 10,000 feet elevation, outside the boundary of Haleakala National Park (Fig. 1). Kolekole Peak is separated by a slight saddle from Red Hill, the highest point on Haleakala (10,025 ft), about one-third mile to the north. The observatory is situated on the high southeastern edge of a sloping, somewhat bowl-shaped area of around 200 acres. Outside this area, the mountain drops steeply to the south and west. The summit of Kolekole Peak offers a nearly unobstructed view of the southern and western flanks of the mountain, but the view to the north and eastward into Haleakala Crater is obscured by intervening peaks. Kolekole Peak and Red Hill are at the summit of the southeast rift zone of Haleakala and are composed largely of fairly recent cinder cone ejecta, although some older rock in the form of cliff faces and talus, is exposed near the observatory. The ground is composed largely of volcanic cinders and rock fragments and is very porous with little evidence of soil formation.

The climate at the summit of Haleakala is a relatively harsh one by

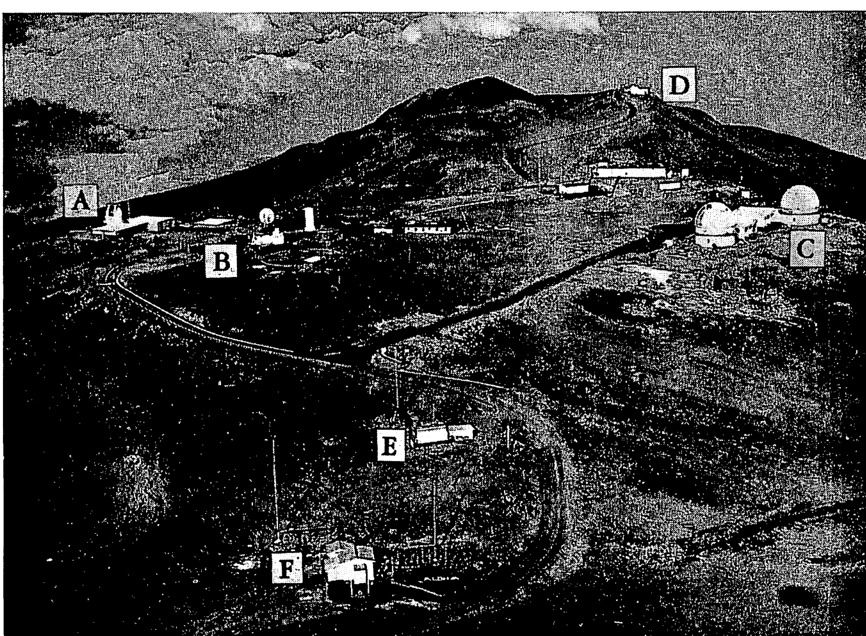

Fig. 1. Summit of Kolekole Peak, Haleakala, Maui, showing areas where aggregations of *Nysius coenosulus* and *N. nemorivagus* were found. A, University of Hawaii observatory; B, summit of Kolekole Peak, 10,012 ft elevation; C, University of Michigan Observatory; D, F.A.A. communications installation; E & F, television relay stations. Photograph by Mr. Larry Ikeda, Wailuku Maui.

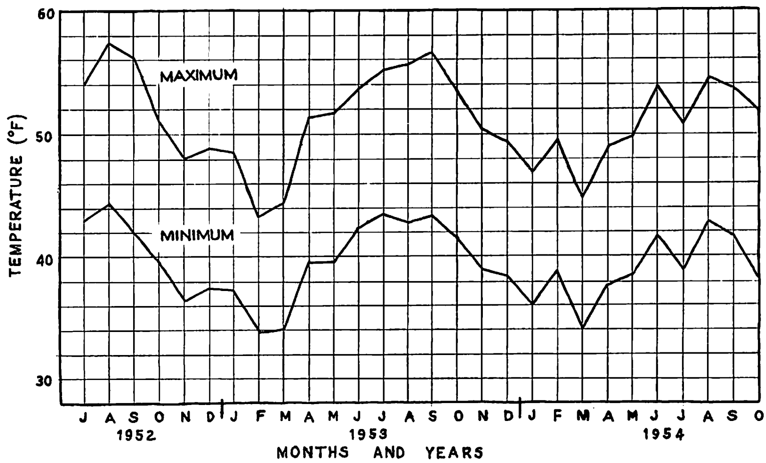

Fig. 2. Average monthly maximum and minimum temperatures at the summit of Haleakala, 1952-1954 (from Reber, 1959).

Fig. 3. Portion of *Raillardia* bush, with aggregating *Nysius* bugs, Kolekole Peak, Haleakala, July 1965. (Photo by C. M. Yoshimoto)

Hawaiian standards. It is fairly dry, with an average annual rainfall of 40 inches and is often windy and generally cool. Highs in the 60's are not uncommon during the summer months. During the winter, minimum temperatures sometimes fall below freezing, and light snowfalls or hail occasionally occur. The graph (Fig. 2) gives an idea of the average maximum and minimum temperatures at the summit.

This environment supports only scattered low shrubs, a little bunchgrass and a few small herbs. The most conspicuous plant on Kolekole Peak is *Raillardia menziesii* (Family Compositae) which occurs as scattered individual shrubs in the summit area and on the slopes (Fig. 3). A few shrubs of *Styphelia* sp. and *Vaccinium* sp. occur on the southern and western slopes just below the summit, and a few bushes of *Coprosma montana* are found 150 feet or so lower. Two species of native bunchgrass, *Deschampsia australis* and *Trisetum glomeratum*, are distributed very sparsely on the summit and slopes. A small decumbent perennial composite, *Tetramalopium* sp., grows in rock crevices on the cliffs and steep slopes around the summit and the prostrate trailing woody *Coprosma ernodioides* is encountered occasionally at slightly lower elevations.

INSECT FLIGHT ACTIVITY AT THE OBSERVATORY

Insect flight activity over high mountain peaks has been observed and reported in various parts of the world (Mani, 1962; Chapman, 1954). Although little has been published on this subject in Hawaii, Haleakala and other high peaks in Hawaii are similar in this respect to other such mountains elsewhere, A few relatively large strong-flying insects were observed flying over Kolekole Peak when wind velocities were around 8–10 knots. (e.g.: cabbage butterflies, *Pieris rapae* (L.) during April, 1965; dragonflies, *Anax* sp.; large blowflies, *Calliphora vomitoria* (L.); and a large syrphid fly, *Eristalis tenax* (L.), on several occasions). However, conical wind-sock insect traps and a malaise trap around the observatory site, as well as observations made by entomologists and observatory personnel, indicated that insect interference was acute only during periods of relatively warm still weather when temperatures were above 50° F., and when wind velocity was 5 knots or less.

Malaise trap catches showed that many kinds of insects may be active in the summit area when weather conditions are favorable. On June 11, 1964, a malaise trap operated at the observatory site during a period of light insect interference and under moderately good weather conditions, from noon until 4:45 P.M., yielded 215 insects representing 9 insect orders and 51 species (Table 1). However, both the malaise trap catches and samples of insects swept from the floor of the observatory dome, following periods of maximum flight activity, indicated that the major portion of the insect interference was due to lygaeid bugs of the genus *Nysius*. Therefore, during this study, the greatest emphasis was placed upon investigations concerning the biology and ecology of these insects.

Table 1. Summary of insects taken in a malaise trap operated at Kolekole Peak Observatory, Haleakala, Maui on June 11, 1964, 12 noon to 4:45 p.m.; wind 0–2 knots, temp. 56°–60°F.

Order	Family	No. species	No. specimens
Odonata			
	Coenagrionidae	1	5
Psocoptera		1	3
Hemiptera			
	Lygaeidae	2	46
	Miridae	1	7
Homoptera			
	Cicadellidae	1	2
	Aphididae	1	5
Neuroptera			
	Chrysopidae	1	4
Coleoptera			
	Chrysomelidae	1	1
	Corynetidae	1	1
	Dermestidae	1	2
	Staphylinidae	1	1
Diptera			
	Tipulidae	2	9
	Sciaridae	2	15
	Cecidomyiidae	1	4
	Chironomidae	2	6
	Ceratopogonidae	1	3
	Dolichopodidae	1	30
	Sphaeroceridae	1	8
	Tephrytidae	2	2
	Sepsidae	1	4
	Agromyzidae	1	1
	Ephydridae	1	1
	Drosophilidae	2	7
	Calliphoridae	1	1
	Muscidae	3	7
Hymenoptera			
	Braconidae	3	12
	Ichneumonidae	3	4
	Eurytomidae	1	1
	Eulophidae	3	14
	Proctotrupidae	1	1
	Prosopididae	1	1
Lepidoptera			
	Noctuidae	1	1
	Pyralidae	2	2
	Geometridae	1	2
	Carposinidae	1	1
	Gelichiidae	1	1
Totals - 9 orders; 36 families		51 species	215 specimens

SPECIES OF NYSIUS ON HALEAKALA

The genus *Nysius* is represented in Hawaii by about 20 native, and one recent immigrant species. Six of the native species were collected in the observatory area of Haleakala during this investigation. In order of their apparent relative abundance in the area, these are *Nysius coenosulus* Stål, *N. nemorivagus* White, *N. communis* Usinger, *N. lichenicola* Kirkaldy, *N. kinbergi* Usinger, and *N. terrestris* Usinger.

Nysius nymphs were collected from several host plants at various elevations on Haleakala and on Oahu to associate properly the nymphs and adults. A portion of the mature (5th instar) nymphs of each lot were preserved, and the remainder reared and adults identified. By this means, a collection of properly identified 5th instar nymphs was obtained which was used to identify nymphs collected subsequently.

The collection and rearing of *Nysius* nymphs showed that 3 of the 6 species listed above breed in the summit area of Haleakala while the others apparently do not. Those found breeding in the Kolekole Peak area were *Nysius communis*, on the flower heads and seed of *Raillardia menziesii*; *N. kinbergi* on flowers and seed of *Tetramalopium* sp., and *N. lichenicola* on seed heads of *Trisetum glomeratum*. Although these 3 species, particularly *N. communis*, were at times moderately abundant, they were not taken in malaise traps or on the observatory dome. Apparently none of these species was of significance as a source of interference at the koronagraph.

Nymphs of the 3 other *Nysius* species were never found in the summit area, although adults of two, *N. coenosulus* and *N. nemorivagus*, were the most abundant, and constituted the major source of insect interference. *N. terrestris* was taken on the summit in very small numbers once in June, 1965.

Of the two most important *Nysius* species, *N. coenosulus* was consistently the more numerous and in every sample outnumbered *N. nemorivagus* by factors from about 2:1 to more than 10:1. For example, a malaise trap (Table 2) yielded 227 *N. coenosulus* and 22 *N. nemorivagus*, while a sample of bugs from under a nearby *Raillardia* bush, taken the same day, contained 558 *N. coenosulus* and 234 *N. nemorivagus*. During both 1964 and 1965, *N. nemorivagus* was rare in *Nysius* populations in the observatory area

Table 2. Summary of insects taken in malaise trap operated at Kolekole Peak Observatory, Haleakala, Maui, October 9, 1964, 11:30 a.m. to 4:45 p.m. Wind about 3–5 knots, temperature 56°F–62°F.

Order	Family	No. species	No. specimens
Homoptera			
	Cicadellidae	1	1
Hemiptera			
	Miridae	2	2
	Lygaeidae	2 (*Nysius*)	249
Hymenoptera			
	Evaniidae	1	1
	Crabronidae	1	1
Totals -3 orders; 5 families		7 species	254 specimens

sampled May through July, although in 1964 it gradually became more abundant during late summer and fall.

AGGREGATIONS

Large aggregations of adult *Nysius*, composed almost entirely of *N. coenosulus* and *N. nemorivagus*, were the most conspicuous faunal element present in the Kokekole Peak area, surrounding the observatory, during most periods of insect interference. The majority of these aggregations were associated with the scattered *Raillardia* bushes (Fig. 3), the bugs being present either on the plants or in the leaf-litter beneath plants, or both, depending upon weather conditions. Smaller aggregations were found at bases of bunch grass clumps in areas where *Raillardia* bushes were absent. Large numbers sometimes were found beneath loose stones or in large rock crevices, particularly during cold weather, but such aggregations were usually beneath or immediately adjacent to *Raillardia* bushes. At times, during the season of maximum *Nysius* activity, large numbers also aggregated on or within certain man-made structures such as buildings, a weather instrument house (Fig. 4), a rain gauge (Fig. 5) and on wooden road markers. In general, distribution of *Nysius* aggregations was rather scattered, and often few or no bugs were found in apparent ideal situations. Usually the larger *Raillardia* bushes with a considerable accumulation of litter supported the largest concentrations of bugs.

Nysius concentrations observed were often impressively large. For example, during January 1964, I estimated that there were between 5,000 and 10,000 bugs present on and beneath one *Raillardia* bush, one of many such bushes similarly infested. Large *Nysius* aggregations were found only

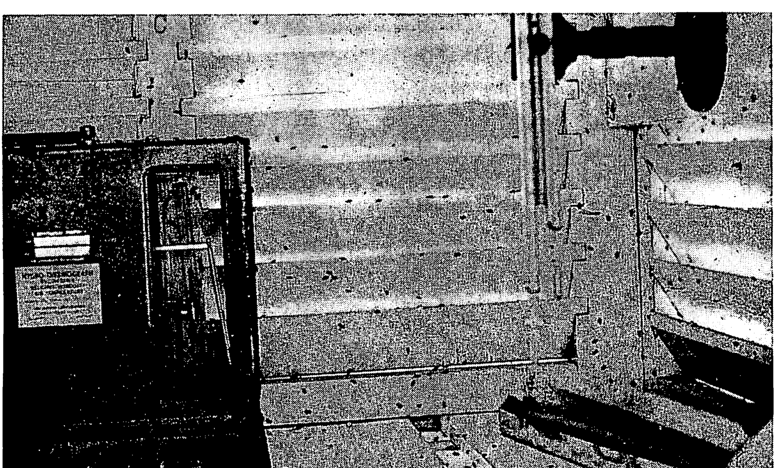

Fig. 4. Interior of weather instrument housing containing numerous *Nysius coenosulus* adults, Kolekole Peak, Haleakala, July 1965. (Photo by C.M. Yoshimoto)

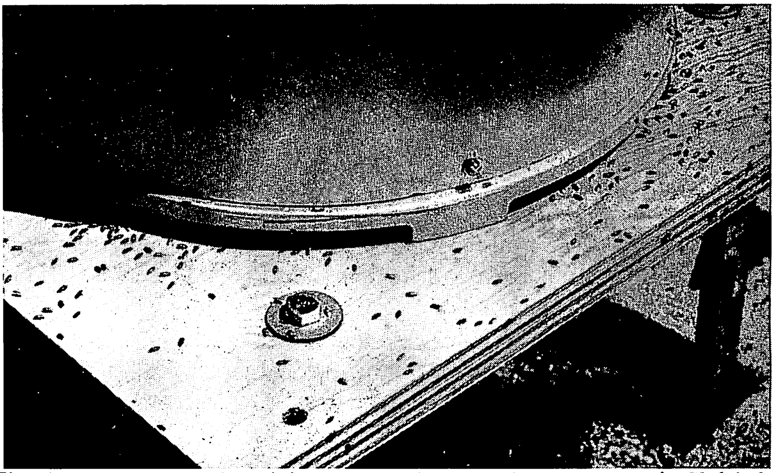

Fig. 5. *Nysius coenosulus* adults congregating on rain gauge stand, Kolekole Peak, Haleakala, July, 1965. (Photo by C.M. Yoshimoto)

within a limited area of about 200 acres including and surrounding Kolekole Peak, and in a smaller area at the F.A.A. communications installation site on an unnamed promontory about 1/2 mile southwest of the observatory. All such aggregations were at an altitude of about 9,700 feet, or above.

On one occasion (July 1965) bugs were fairly numerous at the Red Hill scenic lookout about 1/3 mile northeast of Kolekole Peak, just within the boundary of Haleakala National Park. No large concentrations of *Nysius* were seen or reported elsewhere within the park, although at every visit a search for these insects was conducted in adjacent areas.

Within the Kolekole Peak area, *Nysius* aggregations may move in response to local weather conditions. However, an aggregation which was observed on several unsprayed *Raillardia* bushes near the observatory appeared to remain quite stable over a period of several months. Large numbers were found on and beneath these bushes in late July, 1964, and were present on the same bushes on each of three subsequent visits, the last in mid-November, 1964.

Both sexes of *Nysius* bugs were represented in all aggregrations. Females were somewhat more numerous than males. For example, the 227 *N. coenosulus* adults taken in a malaise trap on October 9, 1964 contained 137 females and 90 males. A sample taken on a white painted surface on July 24, 1965 contained 225 females and 159 males, while a similar sample collected on September 22, 1965 contained 123 females and 105 males.

Reports of National Park personnel and others indicate that *Nysius* bugs have been known to aggregate in the Kolekole Peak area nearly every year for the past 10 years or so (possibly they have done so for many more years), but these concentrations apparently have been confined to that particular area. The only previously published record dealing with *Nysius* aggregations on Haleakala is that of Hardy (1956). He reported that large numbers of *N. nigriscutellatus* Usinger (= *N. coenosulus* Stål) caused clogging of the cooling system filters of a television relay transmitter on Kolekole Peak during June, 1955. Aggregations of *Nysius* species on mountain tops have occasionally been reported from other parts of Hawaii (Beardsley, 1960).

SOURCES AND BEHAVIOR OF NYSIUS AGGREGATIONS

Since nymphs of *N. coenosulus* and *N. nemorivagus* were never found in the Kolekole Peak area or elsewhere on the summit of Haleakala, we assumed that these insects migrated to the summit area from lower elevations. Field studies on Oahu and Maui showed that *N. coenosulus* breeds readily on seed heads of certain common herbaceous weeds of the families Amaranthaceae (*Amaranthus spinosus* and *A. retroflexus*), Portulacaceae (*Portulaca oleracea*) and Chenopodiaceae (*Chenopodium album* and *C. ambrosioides*), and on a native shrub, *Chenopodium oahuense*. None of these plants are present in the summit area of Haleakala, and none were found above 7,000 feet elevation. These are common roadside and pasture weeds at elevations below 3,000 feet in the Kula and Ulupalakua districts, and moderate to heavy populations containing both nymphs and adults of *N. coenosulus* were found on these plants at a number of places along the lower Kula Road, the road between Kula and Ulupalakua, and between Ulupalakua and Kaupo.

The hosts of *N. nemorivagus* on Maui are unknown, and no nymphs of this species were found. Adults of *N. nemorivagus* were collected on flower heads of *Chenopodium oahuense* at 6,000 feet in the Pohakuloa area of Hawaii. I suspect that this species eventually will be found breeding upon this and possibly other species of *Chenopodium* on Maui. *N. terrestris*, taken only once on the summit, is plentiful at lower elevations. It was found breeding upon *Chenopodium*, *Amaranthus*, and *Portulaca*, and often occurred on these hosts in mixed populations with *N. coenosulus*.

N. coenosulus and *N. nemorivagus* undoubtedly are migrating to the summit area of Haleakala from lower elevations, but their origin is uncertain. Surveys for breeding hosts of these bugs were confined to accessible areas of east Maui. However, there are large areas of ranchland and forest reserve, particularly on the southern slopes of Haleakala between 2,000 and 7,000 feet which are not accessible by road; hence, the presence of suitable breeding hosts in these areas was not ascertained. Surveys definitely indicated that large populations of *N. coenosulus* develop on *Amaranthus* and *Chenopodium* weeds at elevations below 3,000 feet on the western and southern flanks of Haleakala. No concentrations of suitable breeding hosts were found on the wet eastern and northern flanks of the mountain or above 3,000 feet in the rangelands above Kula. Except for a few *Chenopodium oahuense* plants at 7,000 feet near Puu Nole, no suitable breeding hosts were found within Haleakala Crater. Surveys along the jeep road from the summit of Haleakala to Polipoli Springs, at 6,000 feet on the southwest rift zone, and in pasture lands of Ulupalakua Ranch Company between elevations of 3,000 and 4,000 feet, above Ulupalakua, were negative also.

Large populations of *N. coenosulus* have been seen on seed heads of *C. oahuense* at 6,000 feet in the Pohakuloa area of Hawaii, and both *N. coenosulus* and *N. terrestris* were found breeding on this plant in the few spots where it was discovered in the Kula area and within Haleakala Crater. Extensive areas of this plant may exist in inaccessible areas on the southern slope of Haleakala. If so, this host could be a major breeding source for *Nysius* bugs aggregating in the summit area. If suitable *Nysius* hosts are absent, it may be assumed that the bugs aggregating on the summit develop largely on introduced weeds which occur in pasture, farm, and wasteland, at elevations below about 3,000 feet on the western and southern flanks of Haleakala.

Observations over the past 2 years indicated that the following annual cycle is characteristic of aggregating Haleakala *Nysius coenosulus* populations. Winter and spring rains in the Kula and Ulupalakua areas promote the growth and flowering of certain weed hosts, principally *Amaranthus* and *Chenopodium. N. coenosulus* populations build up on flower heads and seeds during the spring and summer. After spring rains cease, usually in April or May, these host plants begin to dry up and adult *Nysius* bugs leave and move up-slope, apparently seeking suitable hosts. These bugs begin to aggregate on the summit in June and July and reach maximum numbers in August or September. *Nysius* aggregations remain in the summit area, feeding and flying during periods of favorable weather. Mortality due to low temperatures, senescence, etc., causes a gradual decrease in *Nysius* populations during the winter months. Populations on the summit reach a minimum during February through April, when very few living bugs could be found. Bug populations begin to increase again during May or June as new immigrants arrive from the lowlands.

There is no evidence that bugs reaching the summit area eventually return to the lowlands. Rather, the persistence of *Nysius* aggregations in the summit area, and the large concentrations of dead bugs often seen under stones, in rock crevices, etc., during the latter part of the winter, indicate that nearly all of the bugs reaching the summit area remain there until they die.

Despite the relatively short period during which *Nysius* aggregations on Haleakala have been under observation, it appears that the size of aggregating populations may vary considerably from year to year. Observatory personnel reported that populations present during the late summer of 1963 were much larger than those in 1964. My observations from January, 1964 through July, 1965 indicate that bugs were considerably more plentiful during the early summer of 1965 than during the same period of 1964. These differences in the *Nysius* populations at the summit are believed to be due largely to differences in the sizes of populations developing in low land areas in different years, and probably reflect differences in the amount and distribution of rainfall and the resulting abundance of *Nysius* host plants. Spring and early summer rainfall in the Kula and Ulupalakua areas was considerably heavier in 1965 than 1964 yielding more *Chenopodium* and *Amaranthus* weeds during 1965. In the Ulupalakua area, these plants remained green. Whereas during June, 1964 practically no live *Amaranthus* plants were noted between Ulupalakua and Kaupo. In June, 1965 these plants were plentiful and supported sizable *Nysius* populations. Under conditions prevailing during early 1965, larger *Nysius* populations probably would be produced than under the less favorable conditions during 1964.

Laboratory tests have shown that *Nysius coenosulus* adults held at room temperature (70–85 °F) will die within 2 or 3 days unless provided with a source of food and water. At temperatures below 50 °F these bugs become torpid and remain inactive. Provided they are not subjected to excessive desiccation or to freezing, *N. coenosulus* adults apparently can remain alive for periods of several weeks, possibly a few months, at temperatures below the activity threshold. A sample of several hundred *N. coenosulus* adults, plus a few *N. nemorivagus* adults, collected beneath a *Raillardia* bush near the observatory on October 9, 1964, was held in a closed plastic bag with moist leaf litter, at 40 °F for six weeks. Subsequently, when returned to room temperature, approximately fifty per cent were alive and resumed normal activity. Bugs held in a similar bag, but without leaf litter, all died, presumably due to desiccation.

Further laboratory tests showed that some adults of *N. coenosulus* can survive exposure to temperatures below freezing for several hours. Approximately fifty per cent of several dozen bugs survived and resumed normal activity after 12 hours at approximately 30 °F. Longer exposures to sub-freezing temperatures resulted in progressively higher mortality, but about 10% of the bugs tested revived after 40 hours at 30 °F. Individuals vary considerably in their ability to withstand low temperatures, and this may partially explain the rather gradual decrease in adult *Nysius* populations on the summit of Haleakala during the winter months.

Observations of *Nysius* populations in the observatory area indicate that arriving bugs are attracted to *Raillardia* bushes scattered in the area. Large numbers were often found aggregated between the closely appressed leaf whorls of the apical portions of *Raillardia* twigs, as well as in the leaf-litter beneath these plants. During cold weather the bugs apparently seek more protected situations and were found largely beneath *Raillardia* leaf-litter, around the bases of clumps of bunchgrass, under stones and in rock crevices. Such aggregations usually occurred beneath or within a few feet of *Raillardia* shrubs or other vegetation.

In mid-winter (January) large numbers of dead bugs were found beneath stones and in rock crevices where they apparently had been killed by low temperatures and desiccation. At the same time, a few living bugs were present in moist leaf-litter beneath *Raillardia* shrubs. The presence of moisture, and possibly slightly higher temperatures due to bacterial action, probably permits a greater survival of bugs in leaf-litter than of bugs in rock crevices, etc.

During cold weather (below about 50 °F) or when exposed to wind, the individual bugs of *Nysius* aggregations remained quiescent. However, under favorable conditions, large numbers of bugs from such aggregations were observed flying. These bugs seldom fly when wind velocity is greater than 5 knots, except in protected situations in the lee of cliffs, etc. When in flight, bugs apparently are attracted toward buildings or other white structures; therefore, the bright white observatory dome probably aggravated the interference problem by attracting flying bugs. The attractiveness of white surfaces also was evident by the large numbers found aggregating on and within several white buildings, a white weather instrument housing, and white roadside markers in the observatory area. Bright yellow surfaces also were attractive, but metallic surfaces apparently were less attractive. An experiment conducted at the University of Hawaii, Honolulu, designed to test the attractiveness of various colored surfaces to adult *Nysius* bugs gave disappointing results, possibly because bugs in the population tested were lightly concentrated on their normal breeding host (*Amaranthus*) rather than in the more highly concentrated aggregations characteristic of the summit of Haleakala.

INSECTS OTHER THAN NYSIUS BUGS

Visual observations, malaise trap catches, and samples of insects collected on and around the observatory dome showed that although *Nysius* bugs were usually the principal source of insect interference other insects occasionally became abundant enough to cause difficulty. On a few occasions during spring and early summer when *Nysius* populations were relatively low, such insects appeared to be the major cause of interference.

To illustrate this point, compare Tables 1 and 2. Table 1 summarizes the insects trapped in flight under fairly favorable weather conditions on a day during early summer when *Nysius* populations were relatively low, and Table 2, represents insects trapped in less favorable weather (ie: more wind) during the fall, but when *Nysius* populations were near maximum.

The most conspicuous insects, other than *Nysius* spp., causing interference were several species of Diptera which apparently breed at lower elevations. Large populations of these species were much more transient than were *Nysius* populations, and most disappeared from the observatory area within a relatively short time, usually within a few days of their initial appearance. *Nysius* aggregations, on the other hand, could be found in the observatory area continuously during 8 or 9 months. Some of the other more conspicuous migrant insects are discussed here briefly.

Scaptomyza pallida (Zetterstedt), a small straw-colored drosophilid fly, was abundant both on the observatory dome and on foliage during May, 1965 but virtually had disappeared from the summit area by the middle of June. *S. pallida* breeds in decaying grass and is presumed to have migrated to the summit from pasture lands below. Two dung flies, *Haematobia irritans* (L.) and *Copromyza equina* Fallen, were plentiful also on a few occasions. Blow flies, particularly the large dark blue *Calliphora vomitoria* (L.), and a large syrphid, *Eristalis tenax* (L.), were often seen flying in the area, although never particularly abundant. Once, during April, 1964, large numbers of a tipulid fly, *Limonia* sp., were found clustered on the outside of the observatory building.

Two species of mirid bugs, *Hyalopeplus pelucidus* Stål and *Rhinacloa forticornis* Reuter, were moderately numerous at times in the observatory area, although their numbers were never more than a small fraction of *Nysius* populations. Adults of both of these species were frequently taken on *Raillardia* shrubs in the vicinity of the observatory, and it appears that, like *Nysius*, they feed on these plants after migrating to the summit from lower elevations. Two other endemic species of Miridae, *Cyrtopeltus hawaiiensis* Kirkaldy and *Sarona* n. sp., also occur on *Raillardia* in the observatory area. A brachypterous delephacid leafhopper, *Nesosydne osborni* Muir, often was plentiful on *Raillardia* bushes on Kolekole Peak. These insects were present and apparently active throughout the year, but as they do not fly, were not involved in the koronagraph interference problem.

CONTROL MEASURES

During the spring of 1964 and at irregular intervals thereafter observatory personnel applied DDT, mainly in wettable powder form to foliage of *Raillardia* bushes and other vegetation in the vicinity of the observatory and to the leaf litter beneath these plants. Treated plants, previously the sites of large *Nysius* aggregations, remained almost completely free of these bugs for periods of up to 3–4 months following DDT applications. Large numbers of dead *Nysius* bugs were found frequently in litter beneath plants. However, it was difficult to assess the overall effectiveness of these insecticide applications in preventing insect interference at the koronagraph for the following reasons: 1) The decrease in *Nysius* populations in the observatory area (in comparison with the previous year) observed in 1964 may have been due, at least in part, to factors other than insecticide applications. For example, weather conditions which prevailed at lower elevations on Haleakala during 1964 were less favorable for the development of large *Nysius* populations than during the previous year. 2) Insecticide applications were made only to vegetation in the immediate vicinity of the observatory (mostly within a radius of about 100 yards), and there were sizable concentrations of bugs present outside the treated area. The flight habits of *Nysius* have not been studied thoroughly but these insects may fly to the observatory dome from distances considerably greater than the radius of the area which was treated. More effective control of the *Nysius* bugs might have been achieved if insecticide applications were extended over a greater area of the summit.

There seems to be very little prospect of eliminating *Nysius* populations on their breeding host in source areas at lower elevations due to the very extensive areas of rangeland and farmland apparently involved. Not only would the cost of applying insecticides by air, or otherwise, to such large areas be prohibitive, but also problems of insecticide residues, drift, etc. which would be involved, appear to rule out this approach. Consideration was given to removing all vegetation in the summit observatory area, thereby depriving immigrating bugs of harborage and feeding sites. Esthetically, this did not appear desirable. Also, there is a strong possibility that in spite of the absence of vegetation *Nysius* bugs might still congregate in the summit area. Since plants sprayed with DDT serve as convenient traps which attract and kill arriving bugs, it was felt that this approach should be tried first before attempting control by eliminating vegetation.

One other possible means of decreasing insect interference would involve changing the color of the observatory dome from white to a color unattractive to bugs. If possible, white or bright yellow colors should be avoided on observatory domes and on other structures devoted to any type of work where *Nysius* bugs could become a nuisance.

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